INTER-AMERICAN TROPICAL TUNA COMMISSION

2nd WORKSHOP ON METHODS FOR MONITORING THE STATUS OF EASTERN TROPICAL PACIFIC OCEAN DOLPHIN POPULATIONS

Mexico City, Mexico

09-10 May 2024
(*participation by teleconferencing optional*)

WORKSHOP REPORT

Edited by Andre Punt (workshop Chair)

1. OPENING OF MEETING

The workshop was held on 9 and 10 May 2024 at the Hyatt Regency Insurgentes in Mexico City. It was hosted by the Inter-American Tropical Tuna Commission (IATTC) with funding from the IATTC, the Marine Stewardship Council and the Pacific Alliance for Sustainable Tuna (PAST).

Dr. Mariana Ramos (PAST) welcomed the attendees (see Attachment A for a list of participants and observers), and thanked the IATTC and MSC for support in holding the workshop. She highlighted the importance of the relationship between dolphins and tuna to the industry and expressed hope that the workshop will find way to estimate dolphin abundance and the impacts of fishing.

Dr. Alexandre Aires-da-Silva (IATTC Coordinator of Scientific Research) also welcomed the participants observers, and acknowledged the diversity of the group. He outlined the objectives of the workshop, which were to (a) gather scientific and operational experts specializing in population modeling, abundance estimation, close kin mark-recapture (CKMR), aerial surveying, satellite imagery, cetacean tissue sampling methods and vessel operations; and (b) continue discussion on approaches for monitoring dolphin populations in the eastern tropical Pacific Ocean (ETP), exploring both scientific and operational feasibility aspects, including sampling design, field sampling considerations, timing and budget. He noted that the outcomes of the workshop were (a) a workshop report (this document) summarizing the primary points and recommendations derived from the discussions; and (b) research proposal concept notes for the approaches deemed worthy of further investigation. These will be submitted by the IATTC staff for consideration by the IATTC/ AIDCP (Agreement of the International Dolphin Conservation Program) or external sources of funding.

The workshop was a follow-up to a workshop held during 18-20 October 2016 (Johnson et al., 2018). Dr. André Punt (workshop chair) noted that an aim of the techniques under discussion at this workshop was to estimate absolute abundance with a coefficient of variation (CV) comparable to that of past ship-based surveys. Estimates of absolute abundance could be used to determine the status of stocks relative to management goals, and in harvest control rules for assessing levels of removals due to bycatch that would be consistent with depleted populations recovering and populations remaining at recovered levels once they recover. The primary techniques discussed were digital aerial survey-, close-kin mark-recapture-, and satellite-based approaches. The workshop also considered cetacean tissue sampling methods and vessel operations.

Dr. Punt stated that the primary aim of the workshop (see Attachment B for the provisional agenda) was to identify the advantages and challenges of each candidate technique and develop a series of research proposal concept notes (see Attachment C for an outline) for pilot studies and full application of the techniques. The workshop started with a series of background talks (Section 2 of this report), which was followed by presentations focused on close-kin mark-recapture, digital aerial surveys, and the use of satellite imagery to survey whales and dolphins (Sections 3-5 of this report). Each presentation was followed by an opportunity for participants to ask questions of clarification and raise detailed questions on the methods. The final session of the workshop focused on the feasibility and cost-benefits of a set of research proposals (Section 7 of this report). Two sessions were dedicated to receiving comments and suggestions from the observers (summarized in Section 6 of the report).

2. BACKGROUND

2.1 Outcomes and recommendations of the 1st Workshop

Dr. Punt provided an overview of the 2016 workshop (Johnson et al., 2018). The goal of that workshop was to identify what data types and methods exist to monitor and assess ETP dolphin populations. In particular, that 2016 workshop considered three overarching questions: (a) what methods can provide estimates of abundance with a coefficient of variation (CV) comparable to that from previous line-transect surveys; (b) are there new methods that should be used in tandem to provide complementary information; and (c) if another fishery-independent, ship-based survey could be conducted, could the methodology be improved without reducing the comparability with past assessments?

In addition to ship-based survey methods, which are costly and depend on quantifying the parameter g(0), the 2016 workshop evaluated the use of several tag-based approaches including the use of: (a) conventional and genetic mark-recapture approaches (which can be used to estimate abundance and rates of fishery interaction); (b) telemetry / radio tags (to quantify fishery interactions, dive times, behavior and habitat associations); (c) acoustic and pit tags (to assess fishery interactions and habitat associations); and (d) close-kin mark-recapture methods (which can be used to estimate absolute abundance, survival, and relative fecundity). The likely success of each of these techniques was noted to depend on an appropriate sampling design and overcoming challenges that are unique to each technique (e.g., recapture heterogeneity, and tag loss for conventional tag methods). The 2016 workshop also discussed the utility of acoustics (to estimate g(0) for ship-based surveys), drifting buoys, aerial photographic approaches (including unpersonned sampling devices such as drones), and the use of satellite images. Some of the techniques discussed during the 2016 workshop such as the use of close-kin mark-recapture methods, drone-based surveys and the use of satellites to monitor cetaceans have been extended considerably since 2016.

The 2016 workshop also discussed the various approaches used for the assessments of cetacean stocks, including dolphins, highlighting the data needs and the analytical methods for each type of assessment. This workshop also developed detailed (and costed) research proposals related to ship-based line-transect surveys, close-kin mark-recapture approaches and drone-based surveys.

2.2 Overview of purse seine tuna fishery in the ETP and update on dolphin abundance research since 1st Workshop

Dr. Aires-da-Silva provided an overview of the purse seine fishery for tunas in the eastern Pacific Ocean (EPO) with an emphasis on the tuna-dolphin fishery in the ETP. He noted that there are approximately 10,000 dolphin-associated sets each year and that the high mortality of dolphins in dolphin-associated sets has declined markedly from around 1994 due to changes in operating requirements. Dr. Aires-da-Silva summarized the spatial distribution of dolphin-associated sets, highlighting the multi-national nature of the fishery. He also provided information on the key dolphin species of interest, including estimates of abundance based on the US NMFS ship-based surveys that ended in 2006, and knowledge of stock structure for spotted, spinner, and common dolphins in the ETP. The presentation also summarized the school sizes of captured schools by species/stocks for all spotted dolphin species, eastern spinner dolphins, whitebelly spinner dolphins, and common dolphins for 2022 and 2023.

In discussion, it was noted that the information on stock structure was relatively dated, and that movement of dolphins within the ETP was relatively poorly understood, although this information will be important for developing models to evaluate approaches such as CKMR. It was reported that ~800 dolphin mortalities occur in the tuna-dolphin fishery in the ETP every year, and that each fleet differs operationally and in terms of their spatial distribution.

The meeting requested that the staff provided information on numbers of dolphins encountered by set be plotted to better understand the number of sets that would need to be sampled to obtain a specified number of samples (Fig. 1). The workshop noted that that Fig. 1 was preliminary but that it would help understand the logistics of sampling for CKMR (see also Section 7 of this report).

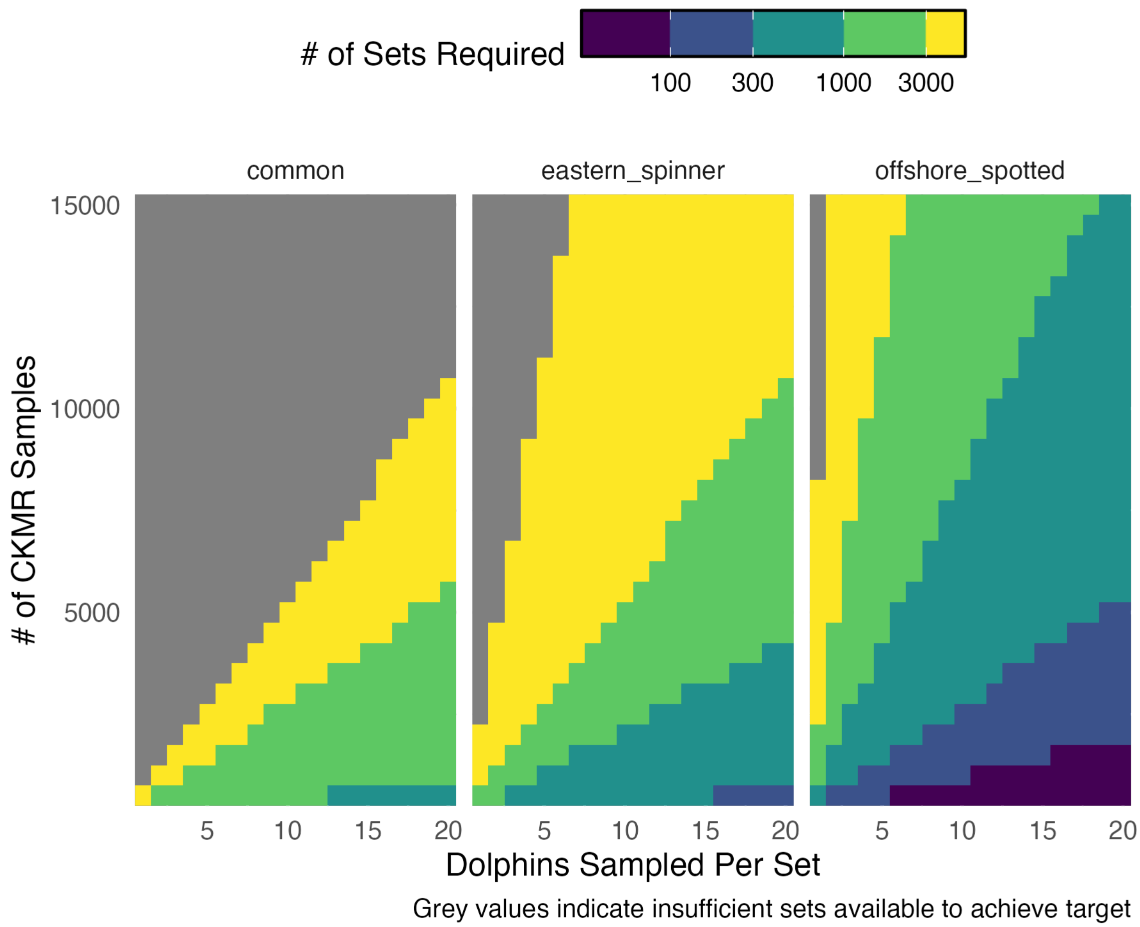

FIGURE 1. Estimated number of sampled sets required (color) to acquire a given number of genetic samples for CKMR (y-axis) given different numbers of dolphins sampled per set (x-axis). Values were estimated based on historic numbers of dolphin-associated sets and associated distribution of dolphins per species per set reported in the observer database. Grey-colored cells indicate that there were not enough sets made in the historic data to achieve the target sample size given the target number of dolphins sampled per set. Color scale is Log-10 transformed.

2.3 Description of the operation of a purse seine set on dolphins in the ETP

Mr. Enrique Urena (IATTC) outlined the stages of a typical set on tunas associated with dolphins, and provided statistics on the schools of dolphins captured by the international purse seine fleet during 2022 and 2023. A systematic methodology has been developed to release dolphins captured in sets. Vessels in this fishery begin their working day by searching for seabirds using high-power binoculars and bird-detecting radars. Once the crew find signs of tuna, the ship's helicopter is sent to check if there are dolphins associated and the amount of tuna present. If several groups of dolphins are present, the captain selects the group with the largest amount of tuna and directs the vessel to its position. When the vessel is close to the school, speedboats begin "herding" the dolphins into a compact group; this stage of the set is known as the "chase". Once the dolphin school, with the tuna underneath, is in the appropriate position to the vessel and the direction of the wind, the crew begin the set by releasing the skiff with the bow ortza of the net attached. The vessel quickly encircles the school of dolphin with an underwater wall of net. When both ends of the net are secured to the vessel, the process of closing the net's bottom starts. A cable passed through rings on the bottom of the net is pulled, and the net is closed, similar to the action of pulling the strings of a purse. Once the bottom cable is retrieved and the net rings come to the surface, the vessel rolls a little more than two-thirds of the net on board; then the vessel prepares for the backdown maneuver to release the dolphins swimming at the surface. The vessel reverses in a slow arc, and the net corks sink, pulling the net out from under the dolphins, releasing the majority from the net. Divers and swimmers help to release any remaining dolphins. Mr. Urena stated that the backdown maneuver has been a remarkably successful way to remove dolphins from the net, while keeping the tuna swimming underneath in the net. Once the backdown maneuver ends, the remaining net is hauled aboard in preparation for brailing the tuna catch into the wells.

Workshop participants requested additional information on the length of sets and the backdown procedure, including its duration and when the risk of entanglement (to dolphins and divers) was greatest. Mr. Urena stated that entanglement occurs most often when the net collapses and forms cavities and when the net is not well aligned because it makes shapes that lead to entanglement.

In discussion, it was noted that for CKMR purposes, it would be necessary to collect data for each sampled individual to minimally identify kinship and age. Age could be obtained from length, although likely at the cost of lower precision estimates of abundance. However, it is now possible to estimate age using genetics data (epigenetic ageing) and this approach has already been applied to dolphins (e.g., Barratclough et al., 2021; Peters et al., 2023). The workshop agreed that it would be worthwhile to create a research proposal concept note to develop an epigenetics application for dolphins in the ETP, and that the necessary calibration step could be based on data (teeth) collected from dolphin mortalities.

The workshop noted that fishery observers are not allowed in the water so any sampling would need to be conducted by the crew, in the water or from the skiff, and that dead dolphins could, in participle, be brought on deck and sampled to obtain for example teeth that could be used to calibrate the epigenetic ageing method. The difficulties working with dolphin mortalities were highlighted by several of the industry participants.

2.4 A review of invasive and non-invasive methods for collecting tissue samples from free-swimming cetaceans

Dr. Heidi Pearson (University of Alaska Southeast) summarized methods for collecting biological and tissue samples from free-ranging cetaceans. These include (in order from least to most invasive): (a)) fecal and sloughed skin sampling; (b) blow sampling; (c) skin swabbing; and (d) biopsy sampling. Key considerations for deciding on the most appropriate method(s) include: (a) human safety; (b) impact on the animals; (c) biological metric(s) of interest; (d) the amount of tissue needed,; (e) sample size; (f) field logistics; (g) permits required (including animal ethics committee review), and (h) personnel training requirements. Dr. Pearson reviewed these methods, identifying the pros and cons for each, considering the aforementioned factors, and with respect to predicted practicality of implementation during a tuna set. The recent experience of a University of Alaska Southeast-AIMM (Associação para a Investigação do Meio Marinho) team aboard a Mexican purse seiner during August 2023 for the pilot phase of the mother-calf separation study provided valuable insight into the practicality of each method (SAC-14 INF-K). Given the considerations above, and based on the experience collecting data aboard a working purse seiner, Dr. Pearson recommended skin-swabbing as the most viable method for collecting genetic data for ETP dolphins during a working tuna set. This method is predicted to yield the best balance of obtaining a high-quality sample while being the least invasive to the animal. Nevertheless, a pilot study is recommended to evaluate animal reactions, logistical practicalities, and sample quality.

The workshop noted that it would be near impossible to conduct skin swabbing underwater but that this could be conducted from a skiff. However, the impact of the collection of samples on vessel operations would need to be accounted for. It was noted that the logistics of how to conduct skin swabbing from skiffs would still be challenging, including how samples would be stored.

The workshop noted that the ideal sample for epigenetic ageing would be a biopsy and the interactions between dolphins could lead to cross-contamination of genetic material, which would negatively impact the ability to obtain ages genetically.

3. CLOSE-KIN MARK-RECAPTURE

Close-kin mark-recapture (CKMR) is a genetics-based method for estimating population abundance that has much promise for improving stock assessments and monitoring programs for data-limited species. Using a modified capture-recapture framework, CKMR can provide estimates of absolute population abundance, natural mortality, and a range of other parameters that are useful for stock assessments without relying on fishery-dependent data sources. Because genotypes are the "marks", CKMR does not require any individual animal to be recaptured and does not suffer from issues related to tag loss or reporting, providing several key advantages over more conventional methods for assessing stock abundance. Though the method is powerful, reliable application of CKMR requires a thoughtful experimental design that is rooted in thorough biological and technical knowledge coupled with an appropriate sampling design. Dr. John Swenson (U. Mass Amherst) described the theory behind CKMR and outlined the key advantages and weaknesses of the method. He then discussed the major factors that need to be considered to ensure that a CKMR project leverages the strengths of the method while avoiding its pitfalls, focusing on sampling design and tissue preservation for successful genetic analysis and kin-finding. Dr. Swenson then provided examples of successful real-world applications of CKMR and delineated the major cost categories that must be considered during project design and implementation (project design, sampling supplies, labwork and genotyping, and analysis – noting that the costs of genotyping are decreasing but personnel costs are not). Finally, to facilitate discussion, he highlighted aspects of cetacean biology that will need to be considered for robust application of CKMR to dolphin populations in the EPO.

Dr. Swenson noted that success application of CKMR necessarily involved several interlinked tasks: (a) a rigorous design phase, ideally involving estimating precision and bias using a simulation model; (b) a way to collect samples that can be processed to provide necessary genetic inputs for application of CKMR; (c) development of a genetic panel that is informative for kinship identification; (d) a pilot study or study to provide baseline estimates; and (e) continued monitoring (Fig. 2).

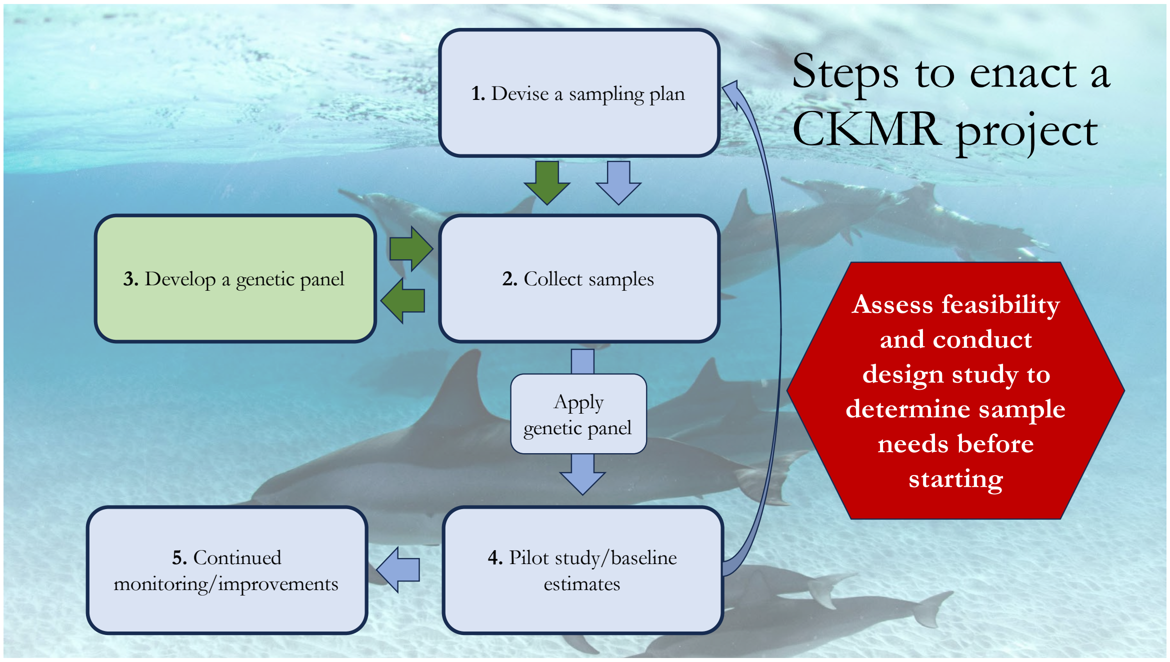

FIGURE 2. Overview of the process of collecting the genetic data needed for a CKMR study.

The workshop emphasized the value and importance of the design phase given each CKMR application is different and the sampling and analysis methods need to be tailored to the case at hand. This, and the need to parameterize simulation models for evaluating CKMR designs, led to the identification of several research activities (see Section 7), including the need to better understand the biology and behavior of ETP dolphins. The workshop noted Fig. 1, and the need to select target species for any CKMR study and the expected precision. While not a research project per se, Fig. 1 should continue to be refined and used in the design process.

Sampling should likely not attempt to collect genetic data for neonates and calves as they are closely associated with their mothers. However, collection of data for juveniles would be useful as it should be easier to assign ages to those animals. This should however be evaluated during the design phase. The workshop also noted that use of half-sibling pairs (HSPs) could be challenging as they are genetically identical to other kin relationships. This may not matter for shorter-lived species but that might be an issue for ETP dolphins where great grandparents might still be around.

The workshop noted that (approximately) 9,000 animals would need to be sampled for a parent-offspring pair (POP)-based CKMR application for a CV of abundance ~0.15, but that this was only an approximate number given the actual number of samples would depend on the biology of the animal, the ability to obtain reliable age estimates, and the use of HSPs. The samples need not be collected in a single year given logistic constraints, but the timing (and location) of samples as well as the number of samples per set should be evaluated during the design phase of any CKMR project. Issues of sample collection and the use of epigenetic ageing is discussed further in Section 7 and Attachments D-1 and D-2.

4. DIGITAL AERIAL SURVEYS

4.1 General issues

In Europe, deployment of digital aerial surveys (DAS) for marine megafauna is a standard monitoring requirement, at least in some marine industry sectors (e.g., offshore renewables). HiDef Aerial Surveying Ltd. (HiDef), an environmental surveying and consultancy company, has developed a bespoke digital video camera rig for deployment through the belly hatch or nose cone of light aircraft. The cameras sample a ~500 m strip width, achieve ~1.7-2 cm ground sample distance and can be rotated and are angled to minimize impacts from sun glare and facilitate high species identification rates, respectively. Surveys are conducted at an altitude of 1,800 ft which offers advantages when surveying marine environments with increasingly tall marine structures. It also poses no risk of causing disturbance / responsive movement of species of interest. Dr. Kelly MacLeod (BioConsult SH GmbH & Co. KG) discussed the strengths and weaknesses of the HiDef methodology in the context of obtaining estimates of abundance for cetaceans. Large scale European population surveys are still reliant on visual observers, yet DAS has largely replaced visual surveys from aircraft and ships for the purpose of characterizing offshore windfarm sites and for pre-post impact monitoring. Dr. MacLeod discussed potential reasons for this, linked to accounting for bias in abundance estimates, and briefly described the use of other platforms in combination with DAS to improve abundance estimation for cetaceans.

In discussion, Dr. MacLeod confirmed that images are currently reviewed manually but that in future artificial intelligence (AI) approaches will be used. She also noted that the Quality Assurance process at HiDef involves an 2nd expert classifying the images, with the review process repeated if agreement is not at least 90% and that in the Bay of Biscay it has been possible to assign 96% of detections to species, even though the schools are mixed. Dr. MacLeod stated that it is possible to apply the methods to large groups such as common dolphins in the Celtic Sea.

The workshop noted that availability bias was a larger concern for aerial-based methods of abundance than for ship-based methods owing to the speed of the plane. Dr. MacLeod stated that work has commenced on techniques for estimating and hence correcting for availability bias, but work remains to be conducted before corrections can be applied.

4.2 Application for the ETP

Dr. Zach Johnston (HiDef Aerial Surveying Ltd) proposed that the coastal waters of the core area of the EPO could be surveyed using HiDef digital aerial survey methods. Aerial surveys could extend ~ 5-900 km offshore depending on the air provider but could potentially provide adequate coverage of coastal spotted (*Stenella attenuata graffmani*), eastern spinner (*S. longirostris orientalis*) and central American spinner (*S. l. centroamericana*) dolphin stocks to contribute to abundance estimation. Costs of digital aerial surveys aircraft versus ships are comparable per day, but the faster survey speeds for aircraft means that transects can be completed in shorter periods of time, thus reducing platform charter lengths. Logistically, the aircraft (s) would need to have ready access to airports (ideally within <100 km of the transect end) situated along the length of the survey stratum coast and as an international survey, required flight permits would need to be in place. However, the use of aircraft to survey inshore waters could be almost an order of magnitude cheaper than using a ship for the equivalent transects. Ships would still be required to survey beyond the aerial strata.

In discussion, Dr. Johnson noted that the King Air 360 can fly faster than 320 km/hr but that this speed was selected to ensure that sufficient images are available. The use of planes such as the King Air 360 is essential for work in the EPO given its larger range compared to the planes conventionally used for aerial survey work (which would cover only ~3% of the EPO). He also stated that processing of images would take a few months given the manual process involved.

The workshop noted that considerable progress has taken place on the use of aerial survey methods since the 2016 workshop but that several issues remained to be resolved, including the difficulties of working in multiple countries and the lack of methods to correct for availability and perception bias. It agreed that there would be value in developing a research proposal concept note on the next steps that would be needed before digital aerial survey methods could be applied in the EPO.

The workshop noted that digital aerial survey methods could be combined with other methods of abundance estimation (e.g., aerial surveys combined with ship-based vessel surveys) and that digital aerial surveys may provide additional data in additional to forming the basis for estimating abundance, such as providing information on marine debris. In principle, the images will be stored for several years and could be re-analyzed years after collection.

5. SATELLITE IMAGERY

The monitoring of marine mammals in the high seas is complex, costly and time-consuming. Hence, the knowledge about the occurrence and distribution of these animals is limited. Using satellite imagery to monitor large whales is a relatively new methodology that enables unstudied, remote, difficult to access and unknown oceanic areas and their species to be studied.

Dr. Caroline Höschle (BioConsult SH GmbH & Co) noted that BioConsult has developed the service SPACEWHALE (https://www.spacewhales.de/) where they use very high-resolution (VHR) satellite imagery to detect cetaceans semi-automatically. In the absence of a library of archival whale snips from VHR imagery BioConsult has trained its algorithm with digital aerial images of the smallest baleen whale, the minke whale and down sampled these to a resolution of 31 cm per pixel. They have developed a methodology that combines state-of-the-art deep learning techniques with a large expert review team to determine the whales to a species level. SPACEWHALE allows large areas of the high seas to be surveyed in a snapshot method that covers 100% of an area, resulting in proper statistics on the spatial distribution and abundance of large whales. Dr. Höschle stated that SPACEWHALE offers an excellent tool to increase data quality and replace or complement vessel/aerial based surveys for the monitoring of animals in areas that are difficult to cover.

Dr. Höschle stated that future developments seem to be promising, with an increased resolution and higher revisiting rate of the satellite constellation. Announcements have been made considering the provision of licenses to collect 10-centimeter commercial panchromatic combined with 40 cm multispectral satellite imagery. The launch of the first satellite is planned for the end of 2025 with a further 27 satellites scheduled to start orbiting the earth by 2028. However, it is common for these missions to be delayed. The satellites will be equipped with advanced sensors primarily developed to capture images over terrestrial areas. Therefore, it will take some time to adapt the parameters for good quality satellite imagery over oceanic areas and work with the satellite image provider to determine the proper environmental conditions to best see cetaceans. No information on cost is available yet.

In discussion, a question was raised about the depth to which satellites can see animals – Dr. Höschle noted that this is currently unknown and more work was needed. The workshop agreed that while satellite-based abundance estimation was possible, the technology is still not sufficiently well developed to be applied at present in the ETP. However, this is an active area of research and the IATTC staff should continue to monitor progress with satellite technology as well as the analytical methods for using satellite images to estimate absolute abundance.

6. SUMMARY OF PUBLIC COMMENTS

There was no public comment.

7. RESEARCH PROPOSALS

A key discussion point throughout the workshop was the importance of understanding the purpose for estimating abundance. It was recognized that none of the methods explored during the workshop would provide high precision estimates of trend in the short-term but that integrating data / estimates of abundance from the proposed research projects with existing data could provide such trends. However, it was also noted that care needs to be taken when comparing estimates from, say, CKMR, with those based on ship-based surveys given each has different biases.

The workshop identified the following general areas of research based on the workshop discussions:

1. Testing whether it is logistically feasible to collect samples from dolphins in sets that provide reliable genetic data for kinship analysis and epigenetic ageing.

2. Development of a genetic panel for each dolphin species that is sufficient for the purposes of providing reliable kinship assignments rapidly.
3. Development of epigenetic ageing methods for ETP dolphins and assessment of the implications of using alternative ways to identify age (e.g., length-class or color).
4. Conducting a gap analysis related to additional information on the biological characteristics (movement, reproductive biology, the possibility of reproductive senescence, age-specific survival, etc) needed to parameterize a simulation model for ETP dolphins.
5. Development of a simulation model to evaluate the likely performance of CKMR given the characteristics of ETP dolphins.
6. Documentation of the steps that will need to occur before it will be feasible to implement a digital aerial survey-based method of abundance estimation.

General areas 1-3 were combined into one research proposal concept note (Fig. 3; Attachment D-1) based on a two-phase approach. The first stage is to assess DNA quality from skin swabs and to evaluate the potential for application of epigenetic ageing methods. Contingent on successful completion of phase 1, phase 2 will involve field testing of skin swabbing and the use of data from dead dolphins to develop a genetic panel. The workshop highlighted that the success of this work would involve close collaboration with industry.

Mr. Alvin Delgado (Chair of the Meeting of the Parties to the Agreement on the International Dolphin Conservation Program, AIDCP) mentioned the possibility for the AIDCP to collaborate on the collection of samples from dead dolphins, but that he was unsure whether it would be possible to obtain sufficient samples given the low number of dolphin mortalities at present. He also stated that the observers would need to train fishers on how to take samples and that fishers were unlikely to be able to get dead dolphins from the water on to a small boat.

Dr. Michael Scott (IATTC, retired) stated that there are data on long-term movements from visual tags that show annual east-west migrations for spotted dolphins (Perrin et al. 1979; Hedgepeth 1985; Scott and Chivers 2009). Radio and satellite telemetry data have provided information on daily movements and showed that spotted dolphin herds are dynamic, aggregating during the day and breaking up at night, and that spotted dolphins travel about 60-134 nm per day (Scott and Chivers 2009). The movement data have been incorporated into line-transect abundance estimation (Glennie et al. 2020).

A group of IATTC staff and industry met during the meeting to discuss the logistics of sample collection, including staffing. The results of these deliberations will be reflected in the research projects, in particular if the pilot study suggests that it is feasible to collect samples that can be used for kinship analysis and epigenetic ageing.

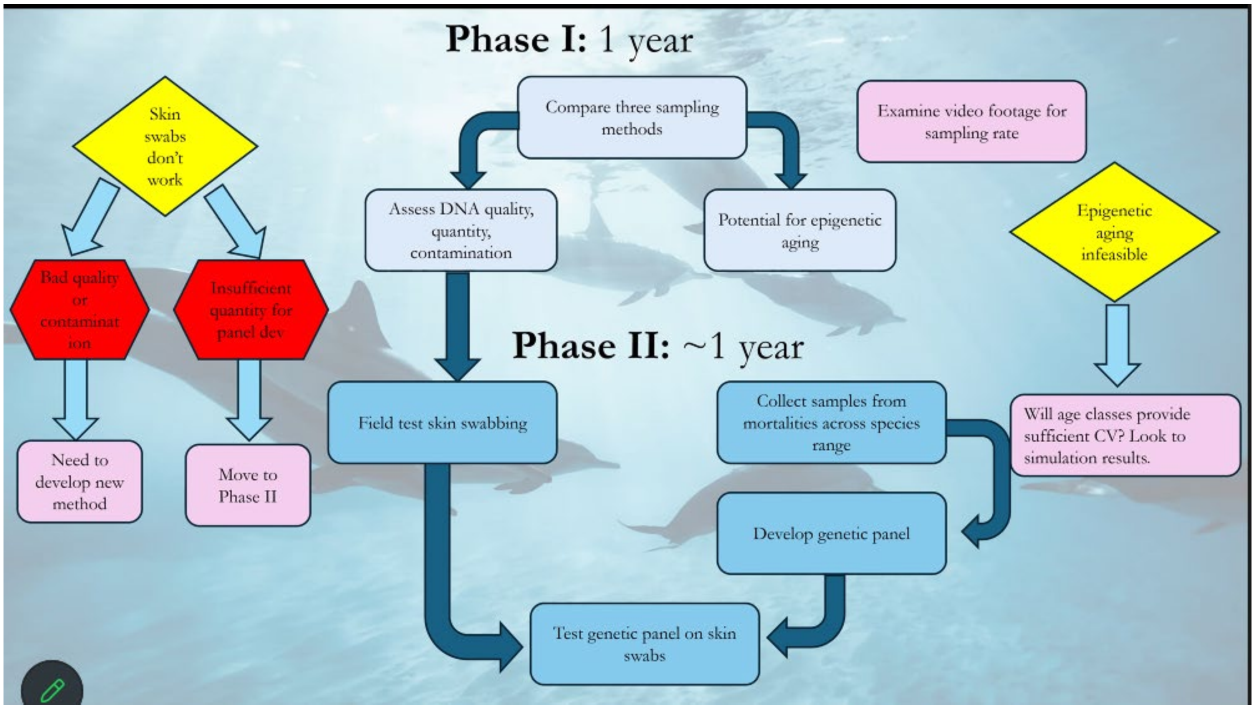

FIGURE 3. Summary of the proposed two-phase process for assessing whether it is logistically feasible to obtain the samples needed for kinship evaluation and epigenetic aging.

The gap analysis and the outline of the process for developing a simulation model to form the basis for the CKMR design are given as Attachments D-2 and D-3, respectively. It was noted that these two tasks are closely related given that the need for additional biological research depends on the simulation model showing that the accuracy / precision of a CKMR-based abundance estimate is sensitive to the associated uncertainty. In principle, the most important factor for which data may be lacking is movement. The time to develop a simulation model will depend on the extent to which "canned" software (e.g., CKMRpop; https://eriqande.github.io/CKMRpop/) can be used – it was noted that the fact that calves stay with their mothers for up to three years could be influential for the performance of the CKMR method and this may not be included in the current generation of generic simulation models.

Attachment D-4 provides information related to the activities that would need to be conducted to enable use of digital aerial survey methods for abundance estimation.

The Chair of the AIDCP explained that the research proposals discussed at this workshop need to be presented to the Scientific Advisory Board (SAB) of the AIDCP. He looks forward to the proposals being presented to the SAB so that they can be considered for funding by the AIDCP.

8. CLOSURE

The meeting concluded noting that some of the project concept notes would be completed after the workshop. The Chair and Dr. Aires-da-Silva thanked the participants for their involvement in the discussions, which will help IATTC as it moves forward to developing proposals for potential funding. They noted the highly collaborative nature of the discussions and thanked for Mrs. Mariana Ramos and her staff with PAST for their work with the planning and the logistics of the workshop.

9. REFERENCES

The list includes references cited in the report and other references of interest provided by Dr. Michael Scott (IATTC, retired).

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Attachment A: Participants and Observers

ASISTENTES - ATTENDEES	
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Attachment B: Provisional Agenda

INTER-AMERICAN TROPICAL TUNA COMMISSION

2nd WORKSHOP ON METHODS FOR MONITORING THE STATUS OF EASTERN TROPICAL PACIFIC OCEAN DOLPHIN POPULATIONS

Mexico City, Mexico

09-10 May 2024
(*participation by teleconferencing optional*)

Thursday 9 May

09:00 Welcome remarks from workshop sponsors (*Mariana Ramos, PAST*)
09:10 Opening address (Andre Punt, Chair)
09:20 Background talk: Outcomes and recommendations of the 1st Workshop (Andre Punt, Chair)
09:40 Background talk: Overview of purse seine tuna fishery in the EPO and update on dolphin abundance research since 1st Workshop (Alex da Silva, IATTC Coordinator of Scientific Research)
10:00 Background talk: Description of the operation of a purse seine set on dolphins in the EPO (Enrique Urena, IATTC Observer Program Supervisor and Manager)

10:30-10:45: Coffee break

10:45 Background talk: A review of invasive and non-invasive methods for collecting tissue samples from free-swimming cetaceans (*Heidi Pearson, University of Alaska Southeast*)
11:15 A review of auxiliary fishery-dependent dolphin data sources available at IATTC (Alex da Silva*, IATTC*)

12:00-13:00: Lunch

13:00 Background talk: Close kin mark recapture (CKMR) (*John Swenson, U. Mass Amherst*)
13:30 Discussion session: CKMR

14:30-14:45: Coffee break

14:45 Discussion session (cont.): CKMR
16:30:17:00 Public comment
17:00:18:00 Outlining report and research proposal concept notes (Chair/IATTC staff/small groups)

19:00: Group dinner

Friday 10 May

09:00 Update from IATTC staff/small groups on research proposal concept notes (IATTC staff/small groups)
09:30 Background talk: Digital aerial surveys (*Kelly McLeod, HiDef*)
10:00 Research proposal: Digital aerial surveys for dolphins in ETP (Zack Johnson, HiDef)

10:30-10:45: Coffee break

10:45 Discussion session: Digital aerial surveys (cont.)

12:00-13:00: Lunch

13:00 Background talk: The potential for surveying whales using satellite imagery (*Caroline Höschle, SpaceWhale*)
13:30 Discussion session: Satellite imagery

14:30-14:45: Coffee break

14:45 Discussion session: Satellite imagery (cont.)
16:30:17:00 Public comment
17:00:18:00 Outlining report and research proposal concept notes (Chair/IATTC staff/small groups)

19:00: Group dinner

Attachment C: Example Research Proposal Concept Note

PROJECT code: Name of project	
Links to IATTC Strategic Science Plan (to be prepared by the staff)	
Objectives	
Background	
Relevance for management	
Pros	
Cons	E.g. impact on fishery operations
Duration	X months, years
Workplan (project staging)	Project phases, chronogram
External collaborators	
Deliverables	SAC reports etc…
Budget (US$)	Itemized budget

Attachment D: Proposal concept notes arising from the discussions during the workshop

Attachment D-1

<table>
<tr><td colspan="2">Sampling feasibility (Phase I) and genetic panel development (Phase II) for CKMR on dolphins in the eastern tropical Pacific Ocean</td></tr>
<tr><td colspan="2">Links to IATTC Strategic Science Plan (to be prepared by the staff)</td></tr>
<tr><td>Objectives</td><td>Phase I
1. Determine number of skin-swab samples from live dolphins that are possible to collect from each set to calibrate time-scale of obtaining sample size goals.
2. Examine quality, quantity, and contamination levels of DNA taken using two different sampling methods.
3. Assess the potential to epigenetically age animals from different tissue samples.
Phase II (once Phase I completes, if successful)
4. Field test skin swabbing.
5. Collect 50-100 samples from mortalities across the population's range.
6. Develop a high-throughput genetic panel.
7. Test the genetic panel on skin swabs.</td></tr>
<tr><td>Background</td><td>Close-kin mark-recapture (CKMR) is a promising method for improving assessments of multiple species of dolphin in the ETP. Being reliant on genetics-based kinship assignment to estimate population parameters, a full-scale CKMR project requires a large number of tissue samples containing high quality and uncontaminated DNA. Constraints related to feasibility and human/animal welfare may impede collection of high quality tissue samples, which would preclude the application of CKMR; alternatively, if these constraints can be overcome, then it may be possible to collect vital information related to stock structure, kinship, and even age from a single tissue sample, which would help facilitate the use of CKMR to monitor dolphin populations in the ETP. Phase I of this project will inform sampling design for CKMR by assessing the number of tissue samples that can be collected from live dolphins from each purse seine set, as well as the utility of samples collected using two different methods that meet the necessary criteria for feasibility and welfare. In addition, the potential to apply epigenetic aging to dolphin tissue will be assessed. The outcome of Phase I will help us assess the feasibility of sample collection for CKMR and, if sampling is deemed feasible, optimize sampling protocols prior to potential application of this promising method.

If Phase I is successful, then Phase II of the project will lay the groundwork for scaling up sampling and genotyping efforts. A team of three researchers will join purse seine fishermen and groundtruth the estimates of feasible sample collection from Phase I while honing the skin swab sampling protocol. Simultaneously, biopsy samples will be collected from mortalities on purse-seine sets across the population's range, and these samples will be used to develop a high-throughput</td></tr>
</table>

	genetic panel that targets DNA regions that are informative for kinship and stock structure. Finally, the genetic panel will be tested and honed using the skin swab samples. Following Phase II, the resources and protocols will be in place for large-scale application of CKMR. It is crucial that sampling is minimally disruptive to fishing operations and safe for the researchers and dolphins, so we have included multiple steps for testing and refining the sampling protocol. More generally, we have several checkpoints in place for this project to ensure that funds are used judiciously and effort is not wasted. As such, Phase II will not commence unless/until Phase I is deemed successful.
Relevance for management	CKMR has the potential to provide estimates of key management quantities that have been challenging to obtain for dolphin populations using alternative methods, including estimates of absolute adult abundance, natural mortality rates, population trend (potentially), and other quantities. If CKMR is deemed feasible for dolphins in the EPO, then the method can provide a baseline estimate of population abundance and a relatively low cost way to track population trends into the future.
Pros	- CKMR has the potential to estimate key population parameters that are vital for population assessments. - Following initial investments in project setup (this proposal) and a baseline abundance estimate, the costs and efforts required for continued population monitoring with CKMR are quite reasonable. - The proposed project includes multiple phases and checkpoints to ensure judicious application of funds, time, and effort.
Cons	- Though the sample collection methods proposed are minimally invasive to the animal, some contact with individual dolphins is required to collect samples for CKMR, which may disturb the animals and pose safety risks for humans (though the proposed methods go to great length to minimize both). - Sample collection may delay fishing operations. However, we have included multiple stages of sample collection and protocol honing to calibrate methods and sample size expectations to keep disruptions as minimal as possible.
Duration	Phase I: 1 year Phase II: 1.5-2 years

Workplan
 	
(project staging)
	Phase I
	
	- Review existing drone footage to assess the likely number of dolphin skin swab samples that can be realistically collected during a purse seine set.
	- Compare DNA quality, quantity, and contamination levels from three different tissue types, all collected from natural mortalities (n=3-10, depending on what is feasible):
	    o Skin swab
	    o Shallow biopsy
	    o Regular biopsy
	- Compare the potential to age animals epigenetically using the above three

	tissue types. **Phase II** - Field test and hone skin swab sampling protocol. - Collect biopsy samples from 50-100 mortalities across the population's range. - Use whole genome resequencing to develop a high-throughput genetic panel that is informative for kinship and stock structure. - Apply the genetic panel to the skin swab samples collected during field testing and hone the panel as needed.
External collaborators	
Deliverables	SAC reports etc…
Budget (US$)	**Phase I:** $20,000 **Phase II:** $245,000 **Total:** 265,000 See table below for first pass of a *rough* breakdown.

Item	Price	Notes
Phase I		
Review video footage	$4,000	
Epigenetic aging	$10,000	
DNA quality/quantity	$2,000	
Sampling personnel	$1,000	
Lab personnel	$2,000	$100/hr x 20 hrs
Bioinformatics personnel	$1,000	$100/hr x 10 hrs
Phase 1 - Total	$20,000	
Phase II		
Field personnel to test skin swabs	$100,000	Three people + flights
Field personnel to collect samples from mortalities (for genetic panel development)	$10,000	
Panel development	$15,000	From meek and larson (2019)
Personnel	$120,000	1 year salary
Phase 2 - Total	$245,000	
GRAND TOTAL	$265,000	

Attachment D-2

Filling data gaps for biological parameters for CKMR abundance estimation.		
Staff: Dan Crear, Melanie Hutchinson, Paul Conn, Dan Ovando, Michael Scott, Heidi Pearson		
Links to IATTC Strategic Science Plan (to be prepared by the staff)		
Objectives	Compile all biological data relevant to CKMR simulation modelling for spotted and spinner dolphins in the EPO. Where sufficient, these may be used directly in developing CKMR models. Where absent, they may be filled in with additional biological studies or through meta-analysis of comparable species.	
Background	CKMR studies require basic biological data to formulate population models and ultimately kinship probabilities. This includes information on age-specific survival, movement, and reproductive output.	
Relevance for management	CKMR can provide estimates of adult population sizes and adult survival but the estimates are dependent on the accuracy of input parameters. Ensuring that the best available data is used for simulation is necessary to reducing the amount of error around the CKMR derived abundance estimates.	
Pros	Allow for greater accuracy in simulation modeling and CKMR outputs.	
Cons	If biological and movement studies are necessary, substantial time and resources will be required.	
Duration	6 months (literature review) to multi-year (if studies are necessary)	
Workplan	1. Conduct a gap analysis of the biological parameters necessary to CKMR simulation for study design. 2. Work with simulation model team to prioritize which gaps need to be addressed and which aren't as influential and can be deprioritized 3. Collection of biological samples (age & growth, reproduction) 4. Meta analysis for parameter determination (borrowing from other species) 5. Conduct biological and movement studies (if necessary)	
External collaborators	Observer programs, industry, academic institutions,	
Deliverables	SAC reports etc…	
Budget (US$)	Sample collection and lab studies	Staff time (literature review)

Attachment D-3

Simulation modeling of dolphin CKMR process	
Links to IATTC Strategic Science Plan (to be prepared by the staff)	
Objectives	Conduct simulation modeling of dolphin CKMR process
Background	CKMR requires a properly designed survey and estimation model to function properly. This phase will develop a simulation modeling framework for generating CKMR style-data reflective of the life history and sampling regimes present in the EPO purse-seine fishery, along with an estimation model that these data will then be passed to. The simulation model will likely used one of the existing simulation frameworks designed for CKMR projects, likely CKMRpop, though the final decision of simulation framework will need to be made after comparison of simulation capabilities with the key biological attributes identified by the dolphin life history review. The simulation model will generate kinship samples along with simulated meta-data based on supplied life history attributes and sampling designs. We will then need to develop a custom CKMR estimation model to estimate the parameters behind the data-generating simulation model. This CKMR model will likely be implement in Stan or TMB. Along with standard CKMR processes, this model will have to account for the possibility of substantial uncertainty in animal aging, as well as movement rates among metapopulations.
Relevance for management	Successful completion of this project will provide management with information on the number of samples of different kinship pairs required to achieve a desired level of prediction on parameters of interest, such as absolute abundance of target species. It will also help us understand what levels of aging precision are required for achieving desired outcomes, and what parameters can be reasonably expected to be estimated conditional on the biology and sampling constraints present in this system.
Pros	Will provide scientific basis for decisions around required sample sizes and data quality, as well as grounding expectations of the type of parameters that can be estimated and their likely precision.
Cons	The primary con for this project is use of staff and collaborator time
Duration	12 months+
Workplan **(project staging)**	- Selection of simulation modeling framework based on collaboration with findings of life history review team. - Learning functioning of selected simulation modeling framework - Parameterizing and running simulation models - Review and validation of simulation process - Development of CKMR estimation model - Testing of CKMR estimation model on based on fixed-parameter data generation (i.e. ability of the model to correctly estimate parameters used to generate data from the model itself) - Conditional on satisfactory performance of CKMR estimation model on internally-generated data, fit CKMR model to range of simulation scenarios - Evaluate CKMR performance metrics of interest as a function of simulation

	states - Provide recommendations on CKMR sampling design and likely outcomes based on simulation study
External collaborators	Paul Conn John Swenson Mark Bravington
Deliverables	SAC report, potential publication
Budget (US$)	Staff time

Attachment D-4

Estimation of absolute abundance of ETP dolphin populations from Digital Aerial Surveys	
Links to IATTC Strategic Science Plan (to be prepared by the staff)	
Objectives	**Objective:** Completion of a survey to test the field and statistical methods to enable absolute abundance of priority dolphin stocks in a subarea of the core ETP to be estimated from Digital Aerial Survey (DAS) **Phases:** 1. Development: Statistical analysis & digital camera rig 2. Survey implementation (including survey design) 3. Data processing and reporting
Background	HiDef Aerial Surveying Ltd. have been working with the University of Auckland, New Zealand, to investigate how unbiased abundance estimates can be generated from HiDef Digital Aerial Survey (DAS). In July 2022, HiDef undertook a double platform (2 aircraft) DAS and applied a novel cluster capture recapture (CCR) method (Stevenson et al. 2019) to estimate the absolute abundance of harbour porpoise (*Phocoena phocoena*), correcting for time spent below the surface (availability). Whilst CCR proved computationally efficient to use, the field and analytical methods necessitated the use of two survey aircraft, a more costly exercise, both financially and in terms of carbon contributions. To meet the challenge of conducting DAS in the ETP we will develop a solution comprising a bespoke camera rig on a single aircraft and a statistical approach to generate unbiased dolphin abundance estimates from the DAS. The aircraft endurance limits the extent of the ETP that can be surveyed; we focus on surveying within the core stratum. HiDef currently works with a US service provider with a suitable long-range aircraft (King Air) allowing us to maximise the offshore extent of the survey stratum. To demonstrate capabilities, we propose ~17,000km of survey effort within substrata of the traditional core survey block and Gulf of California. This can be achieved in 18 aerial survey days for a cost of 1.16m$; for comparison, the cost of ship charter alone to achieve 17,000km of transect amounts to ~3.7m$. At a third of the cost, the development work to realize a DAS in the ETP presents a cost-effective approach for long-term monitoring of dolphin stocks.
Relevance for management	Further development of digital aerial survey methodologies has the potential to provide estimates of abundance for priority dolphin stocks in the ETP. There has been a hiatus in up-to-date absolute abundance estimates due to the prohibitively expensive shipboard surveys. Introduction of DAS offers a solution to long-term monitoring of absolute abundance and trends. DAS also enables data collection on multiple taxa and activities (inc. AIS) simultaneously; including other species of interest (e.g. tuna) and activities (e.g. fishing). Such data might contribute to other data gaps/management evidence requirements.
Pros	- Aerial surveys are more cost effective that shipboard - Aircraft can be readily mobilized to take advantage of suitable weather windows - No reliance on human observers, reducing health & safety issues - High flight altitudes (>1600ft), large swathes (>500m) and high resolution (GSD = 2cm)

	- Cameras are angled (increases species identification rates); can be rotated (minimize glare) - Multi-taxa/activity data can be collected and are fully auditable. - Object detection algorithm will in future reduce costs. - Improved school size estimation and recording of multi-species schools - Following initial investment, ongoing costs for any future surveys would likely be reduced.
Cons	- DAS surveys are a well-established and widely implemented methodology - Non-invasive and high flight altitude poses no threat of disturbance to marine megafauna - Requires suitable survey environmental conditions for flights to mobilise
Duration	Tentative phase timetable depending on funding: **1.** Development: Statistical analysis & digital camera rig – October 2024 – June 2025 (9 months) **2.** Survey implementation (including survey design) - July – August 2025 (2 months) **3.** Data processing & Reporting – September – March 2026 (7 months)
Workplan **(project staging)**	**1. Development: Statistical analysis & digital camera rig** The statistical approach to abundance estimation from multi-camera DAS data is based on mark-recapture distance sampling (MRDS) methodology. It can be achieved by developing a camera rig with three forward- and three reverse-pointing cameras. Each array of three cameras captures a strip of width ~400 m, and the time delay between the forward and reverse images creates a mark-recapture setup in which dolphin schools that are undetected by the forward-pointing cameras have a chance of being detected by the reverse-pointing cameras, and vice versa. The rig can theoretically achieve time delays of up to 30 seconds. A ~2cm GSD will be achievable to enable high species identification rates. The rig will be tested in a UK trial, and footage reviewed to ensure required specification is met. Additional statistical development is required for data analysis, ideally informed by previous survey data: • Determine the optimal time delay between forward and reverse camera images to balance effective sampling of the surface/dive cycle against the degree of animal movement and identification uncertainty; • Create a method for assembling digital detections of individual dolphins into schools; • Create a movement model at the school level, acknowledging that some schools will be only partially within the camera view; • Create a method for estimating school size, acknowledging that not all animals in a school may be simultaneously detectable; • Evaluate methods already developed for handling uncertainty in duplicate matching; select and refine based on precision and accuracy from data-informed simulations; and • In all steps above, recognise that DAS provides a GPS location for each detection, which is not conventionally available (although HiDef have recently developed the approach). Methods will need to be adapted to exploit this new information.

2. **Survey implementation (including survey design)**

To maximise the offshore extent of the survey stratum, we propose to use at least a King Air 360 (endurance 2,100km) to conduct the survey and an illustrative design/cost is based on that premise. In the absence of any pilot data, we aimed for a survey that is achievable over 2-3 weeks of airtime; the resultant design requires 18-days of survey time in the required survey conditions. Two survey strata are identified: Core_DAS (3m km^2) and Gulf of California (GoC) (0.25m km^2). HiDef's North American Programme Manager (NAPM) and HiDef's operations team will manage the aerial operations. The bespoke survey rig will be shipped in advance of the survey to be fitted, and tested, in the aircraft by HiDef engineers. HiDef is currently working with an air service provider that can service the ETP region. Key to success is the identification of airport/airstrip locations for daily refuelling. Multiple-country approvals for flights will need to be secured ahead of the survey. Digital video imagery and GPS data are recorded continuously to solid-state hard drives. At the end of each survey, hard drives will be collected and the NAPM will manage the data transfer to the UK for processing.

3. **Data processing & Reporting**

We provide a detailed QHSSE survey completion report within seven working days of survey completion; a survey log, brief description of the survey and any issues. If timescales allow, we will use our automated object detection algorithm (HiDeFIND[1]) to review survey footage and our expert identification team for species ID. All data collection and processing is tightly defined by our internal Quality Management System. HiDef will provide a final report with an overview of all data collected but will focus on the methods developed for estimating dolphin abundance. The report will include detail of the analysis, abundance estimates for the priority species, together with recommendations for further work. The statistical method will be made available in an R package.

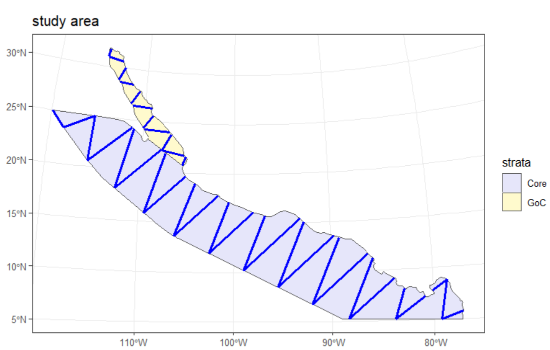

Figure 1: Example zig-zag survey design for DAS

External collaborators	
Deliverables	• Raw data • GIS items - All survey data and results will be presented as digital deliverables for integration into a Geographic Information System, • R package of the analysis approach developed

[1] HiDef request that identified dolphin images can be made available to them and contribute to the training dataset for the AI.

	• Final report
Budget (US$)	(see nested table below)

Phase	**Work package**	**Description**	**Cost ($)**
1.	WP 1: Digital camera rig development	Bespoke rig development & UK trial flight	83,136
	WP2: Statistical analysis development	Development of statistical method for absolute abundance estimation of priority dolphin species	20,000
2	WP3: Survey Implementation	Survey design; Rig shipping, installation, test flight. Completion of survey flights - data acquisition (18 days) and processing* (17 days)	1,015,799
3	WP4: Data processing and Reporting	Survey completion reports; Final report	35,863
	TOTAL		1,154,798

*The use of HiDef's AI algorithm (being rolled-out currently) will ultimately also bring cost savings to data processing.